Reducing curtaining effects in FIB/SEM applications by a goniometer stage and an image processing method

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In the last two decades focused ion beam (FIB) systems are used for sample preparation. For example either the edges of a sample can be polished for analytical measurements or continuous cross sections can be milled for 3D tomography and reconstruction. The main disadvantage of both procedures is the so called curtaining effect, i.e. increasing surface roughness in direction of the milling depth. The roughness of the cut can influence the result of the measurement and the segmentation process. In the present study, we report about two different ways to reduce the curtaining effect, namely a hardware and software technique:

First, Tescan implemented the so called “rocking stage” in their plasma FIB[1]. For the NSC’s FEI gallium FIB system a home-made goniometer stage is installed, which can be adapted if needed. With this relatively inexpensive solution the sample can be rotated around an additional axis and tilted by ± 8°. Different sample heights are possible and the edge can be polished and imaged without stage movement. However, for automated milling and imaging procedures such as 3D tomography a tilting stage is not feasible.

As a second possibility, an image processing method is proposed that can be applied after the milling procedure on the whole image stack. In Fig. 1, an unprocessed 2D secondary electron image of the heterogeneous microstructure of an aluminum matrix composite (AMC) reinforced with silicon carbide (SiC) particles is shown. Beside a strong curtaining effect additional discontinuities caused by redeposition of previously removed material can be seen in the lower part of the image. A novel variational method for mathematical image processing is developed to reduce milling artifacts. The method is applied to the whole 3D dataset and the distortions are reduced by using their special structure and directional dependence (see Fig. 2). The resulting new image stack is used to compose a 3D volume reconstruction. The geometries of the SiC particles can be measured without any milling artifacts.

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1 J. Jiruse, M. Havelka, J. Polster and T. Hrncif, Microsco. Microanal. 21 (Issue S3), 0996 (2015)

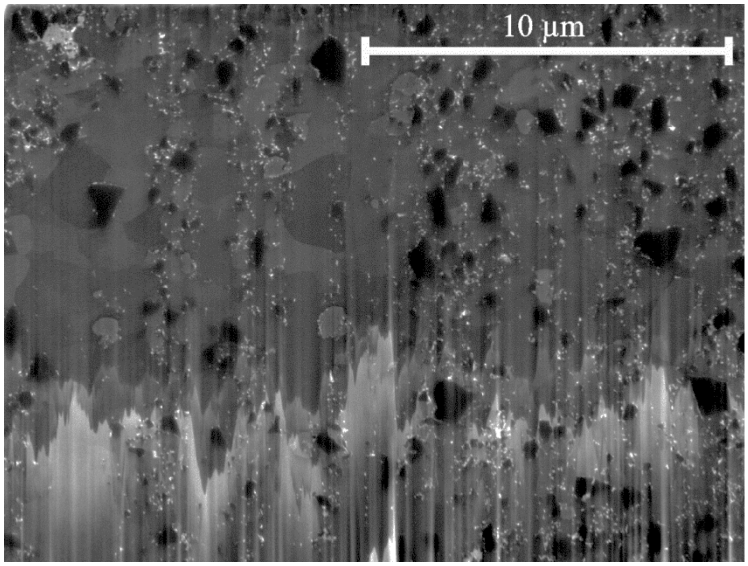

Figure 1: Secondary electron image of an AMC sample after FIB polishing. The sample consists of the aluminum matrix and SiC particles (dark areas). The curtaining effect can be seen as vertical lines. In the lower part of the image additional discontinuities in brightness and contrast can be observed due to redeposition of milled material.

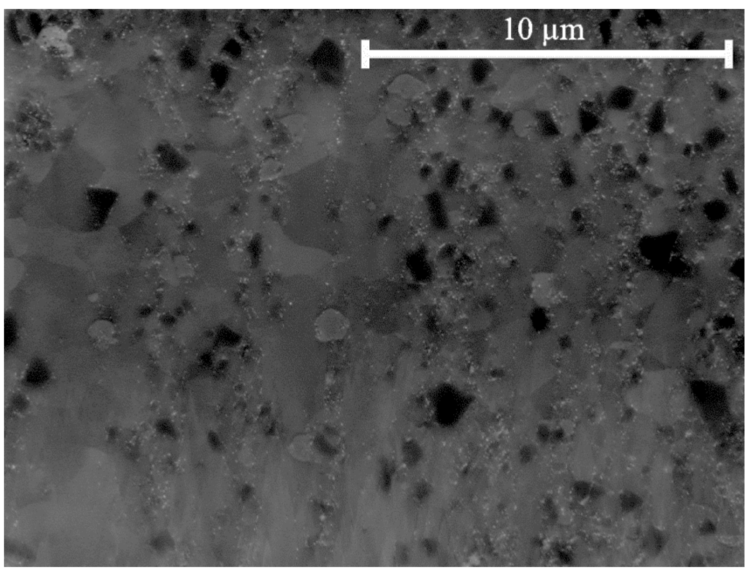

Figure 2: The same secondary electron image after applying the mathematical method. Artifacts are reduced and SiC particles are now clearly visible.